UTILIZATION OF WASTE

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USE OF GALVANIC SLIME IN PRODUCTION OF CERAMIC FACADE TILES

A. K. Abdurakhmanov,[1] A. M. Éminov,[1] and G. N. Maslennikova[1]

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The physicomechanical properties of galvanic-production slime are investigated. The possibility of using this slime as a flux in ceramic mixtures is demonstrated. Optimum mixture compositions containing slime are developed for facade tile production.

Enormous quantities of waste generated by the chemical, power, machine-building, electronic, and mining sectors of industry have been accumulated in industrial regions of the Republic of Uzbekistan, and waste utilization is a very topical problem. Such waste includes galvanic-production slime, which so far has not been recycled, due to insufficient knowledge of its properties and lack of technology for its application.

The purpose of the present study was to determine the possibility of application of galvanic slime in the production technology for ceramic materials and develop optimum ceramic-mixture compositions with maximum content of such slime.

We investigated wastes generated by large industrial enterprises: TAPOiCh Joint-Stock Company, Algoritm Works, and Uzélektroapparat Works. Galvanic-production waste cannot be dumped into rivers and ponds without neutralization, and its purification by standard mechanical and biochemical methods is impossible. Neutralization of acidic or alkaline sewage waste produces sediments, which are usually called galvanic slimes.

Study of the properties of galvanic slimes suggests the possibility of their application in production of ceramic materials. The chemical composition of the investigated slimes is shown in Table 1.

A special feature of the slimes is a high content of iron oxides, especially ferrous oxides, and the presence of oxides of alkali metals and alkali-earth metals. It is known [1, 2] that iron, sodium, and potassium oxides have a strong fluxing effect in the course of ceramic-mixture sintering. Calcium oxide fosters a decrease in shrinkage, and increases the strength and cold resistance of ceramic materials [3, 4].

The average moisture content of the wastes considered is 18 – 22%. The color varies from white to brown, depending on the coloring-oxides content. The calcination loss is 7 – 11%, and the melting temperature is 1120 – 1180°C. The granular composition of the slimes is polyfractional, the particle size varies from 0.2 – 0.5 μm to 0.5 mm. Sifting-analysis results are shown in Table 2.

Electron-microscopic analysis of the slimes was performed using an ÉMV-100 instrument. The sample of Algoritm Works slime is characterized by an amorphous structure, the particle surface is rough, and extremely small quartz crystals are present in the sample.

The slime sample from the Uzélektroapparat Works consists of fused and amorphous particles, and no traces of crystals are observed. The photographs show an accumulation of globules, and the sample structure is homogeneous. The surface of the particles in the slime sample from TAPOiCh JSC is distinguished by a higher degree of crystallization. This is possibly due to the presence of $CaCO_3$ crystals in the form of plates formed in the course of sedimentation.

Differential thermal analysis revealed the presence of two endothermic effects that point to the processes of decomposition and disassociation. The first endothermic effect at temperatures of 150 – 180°C is related to removal of residual moisture, and the weight loss here is 11 – 14%. The increased temperature of moisture removal can be accounted for by the strong bond of water in the hydrate shells around the particles due to the high dispersion of the slimes. The second endothermic effect with a maximum at 780 – 840°C is related to decomposition of salts and release of CO_2, SO_2, etc. These processes are accompanied by a weight loss of 20 to 25%. The crystallization process is not observed up to a temperature of 1000°C, which is supported by the lack of exothermic effects.

[1] Russian Academy of Management, Moscow, Russia; Tashkent Chemical Engineering Institute, Tashkent, Uzbekistan.

TABLE 1

Galvanic slime from companies	Weight content, %													
	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MgO	MnO	CaO	Na_2O	K_2O	P_2O_5	SO_3	CO_2	H_2O	calcination loss
TAPOiCh JSC	8.69	4.69	5.15	3.35	1.30	0.02	20.05	2.27	2.07	0.29	4.84	4.06	8.90	31.37
Uzélektroapparat Works	12.95	3.03	4.46	3.49	1.35	0.04	12.04	3.77	2.05	1.48	4.37	4.98	9.02	36.97
Algoritm Works	10.70	0.16	4.91	6.19	2.90	0.07	15.34	2.13	2.13	1.19	1.78	9.58	7.62	35.30

TABLE 2

Sieve number	Cell size, mm	Residue on sieve, %	
		total	fractional
12	0.5	0.34	0.35
24	0.25	0.66	0.31
70	0.08	0.93	0.26
80	0.075	0.91	0.04
100	0.063	1.04	0.10

Thus, the chemical composition of the investigated slimes meets the requirements imposed on fluxes used in ceramic mixtures. The content of CaO in the slimes (up to 20%) points to a positive effect of its compounds on the properties of ceramic materials. The slimes mostly have an amorphous structure, and they melt at relatively low temperatures, readily form eutectics, and actively enter into reactions. Use of the slimes in ceramic technology makes it possible to eliminate coarse grinding [5, 6].

Based on the data obtained, slime-containing ceramic-mixture compositions were developed for the production of facade tiles. The mixture composition used at the Tashkent Construction Materials Works was taken as a reference standard.

Experimental mixtures were prepared in accordance with slip technology, and the components were milled in a ball mill to a residue of 1.5 – 2% on a No. 0063 sieve. The prepared slip was dried in a drying cabinet, and the cakes were crushed and sifted through a sieve with a cell size of 1 mm. The moisture content of the resulting molding powder was 7 – 8%, and its granulometric composition was as follows: content of the 1 mm fraction – 2%, 1.0 – 0.5 mm – 20%, 0.5 – 0.25 mm – 32%, below 0.25 mm – 45%.

Experimental samples of size 150 × 150 × 10 mm were molded on a KRK-125 press under a final pressure of 10 – 12 MPa. The molded and dried samples were fired in a roller conveyer furnace at temperatures of 1000 – 1080°C for 40 – 50 min. After firing, the main physicomechanical parameters of the samples were determined, and their values varied within the following limits: water absorption 6 – 8%, shrinkage 2 – 3%, bending strength 18 – 25 MPa.

Analysis of the results indicates that the optimum compositions are those containing 7 – 12% galvanic slime.

After the first firing, the experimental samples were decorated with industrially produced transparent and tinted opaque glazes. It was found that the majority of the glazes can be used in the production of ceramic articles with a slight adjustment of their composition.

Thus, the integrated evaluation of the galvanic-production slimes established the possibility of their application in production of silicate materials.

Use of the slimes as a recycled material makes it possible to reduce the consumption of scarce and expensive mineral materials, reduce the unfavorable effect of technogenic products on the ambient environment, and improve the economic parameters of production by decreasing production costs.

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